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1907



The Engineering Building
of the
University of Pennsylvania

UNIVERSITY OF PENNSYLVANIA

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of the

University of Pennsylvania

Being a reprint of a description prepared by Mr. H. J. Kennedy, Associate Editor of the "American Machinist," and appearing in that paper for October 25 and November 8, 1906, together with a reprint of a description of the illumination of the building prepared by the General Electric Co. and appearing in the "American Machinist" for December 27, 1906.

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Press of
THE JOHN C. WINSTON CO.
Philadelphia, Pa.

The New Engineering Building of the University of Pennsylvania.

\$800,000 Home of the Departments of Mechanical, Electrical, Chemical and Civil Engineering
Its Plan and Equipment.

THE new engineering building of the University of Pennsylvania, in Philadelphia, is one of the most recent examples of a building designed for the instruction of students in engineering, and is attracting considerable attention; the formal dedication, on October 19, makes this an opportune time for presenting the following description.

The building, of which a photographic view is given in Fig. 1, is the largest of the University group of seventy buildings, having a front 300 feet long and being 210 feet deep at the west end, 160 feet deep at the east end. It is situated at the northeast corner of the University's grounds; its eastern end is bounded by Thirty-third street, and its front faces a walk of the campus which is a continuation of Locust street. Its cost with equipment was approximately \$800,000. It contains three stories, and under a portion of it is a basement, the space in which is

also fully utilized. The building is of structural steel incased in concrete, with an exterior of dark



Fig. 1.—View of the Engineering Building from the Southwest.

brick with limestone trimmings, the general architectural treatment being in the English Georgian style. The total floor area is about 128,000 square feet. The heating is by direct steam, the exhaust

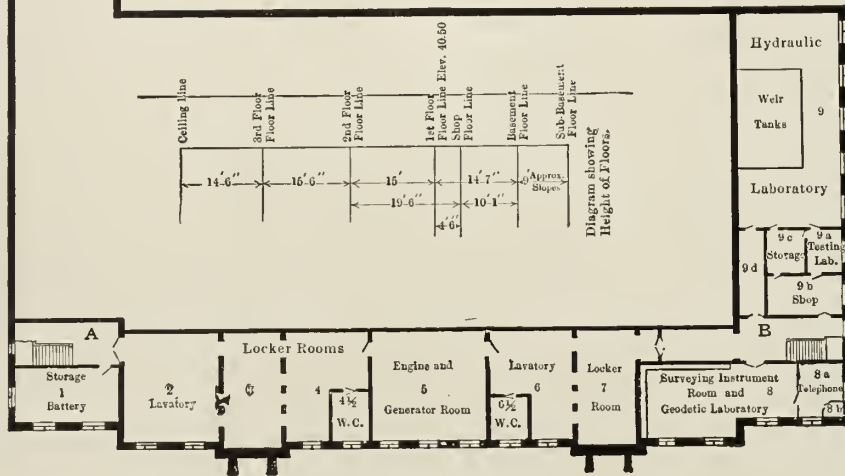


Fig. 2.—Basement Plan.

from the engines being utilized for this purpose. The ventilation is by electrically driven blast fans located in the attic and in the basement, the ventilating system being divided into sections. The switches and controlling mechanism for the fan motors are placed in the various rooms of the building so that it is not necessary to leave the room to control the ventilation. While air is

forced into the building in general, the opposite is the case for the toilet rooms, a very practical system being in use for their ventilation. Ducts are led to exhaust fans from the bowls of the water-closets, so that the rooms are practically odorless.

The building is virtually divided into two portions, the larger portion, which will be described in detail first, being that devoted to the needs of the students in mechanical, electrical and chemical engineering; the smaller portion, at the east end, is designed for the students in civil engineering.

THE BASEMENT

Fig. 2 is a plan of the basement. At the east and west ends are staircases leading to the main corridor above. At the south-west corner is a room contain-

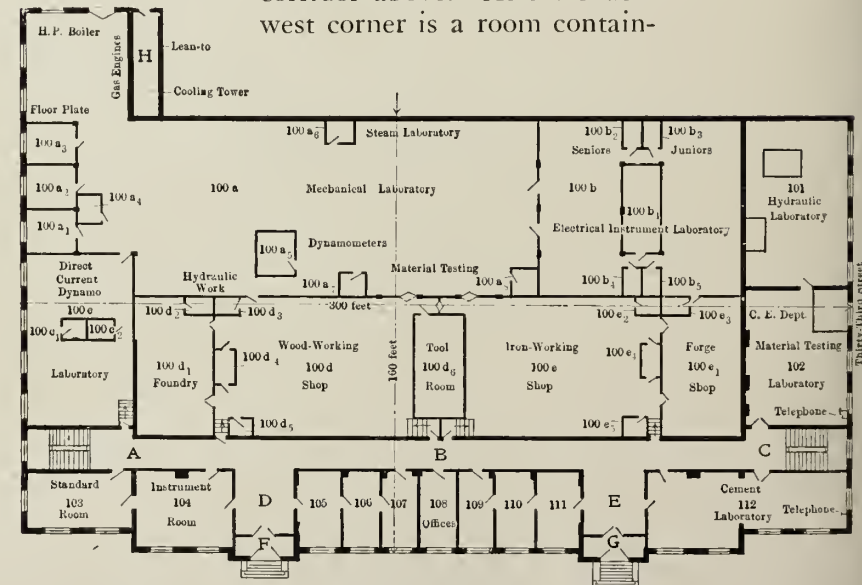


Fig. 3.—First Floor Plan.

ing the principal storage battery, particulars of which will be given in connection with the description of the electrical equipment. Next to the east of this are very nicely appointed lava-

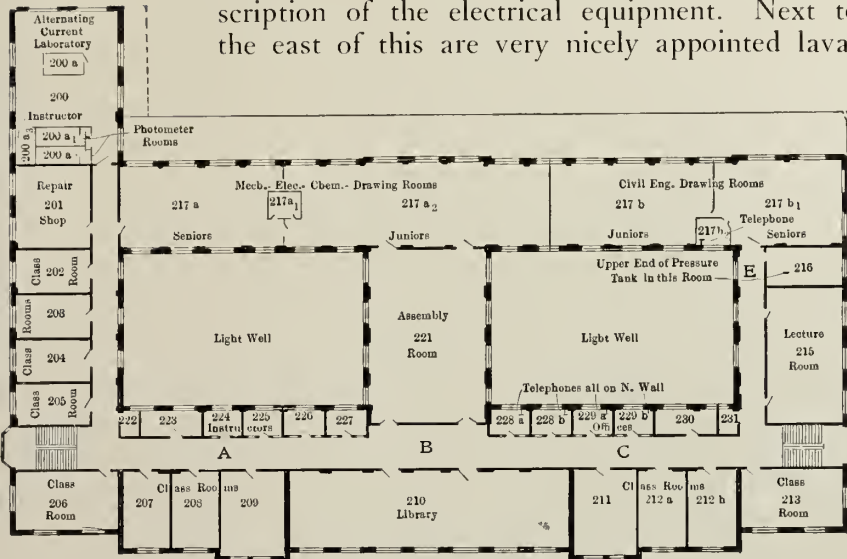


Fig. 4.—Second Floor Plan.

tories, locker rooms and toilet rooms, the locker rooms containing numerous Merritt expanded-metal lockers, one being assigned to each student. In the middle of the building is the engine room, containing high-speed engines and direct-connected generators, supplied with steam by an underground pipe line from the main boiler plant of the University, which is not far distant.

The current used throughout the building, with exceptions, such as certain alternating currents used in the laboratory and generated there, is direct current with an electromotive force of 110 volts. To the east of the engine room are lavatory and locker-room accommodations for the civil-engineering students, and laboratories and shops of the same department, which will be described later.

THE MAIN FLOOR

Fig. 3 is a plan of the first or main floor. It will be seen that there are two entrances, one near the east end and one near the west end, the former leading direct to the mechanical-engineering department, and the latter to the civil engineering. There is, however, a spacious corridor running the full length of the building and terminating at each end in staircase shafts. This corridor, like a large portion of the remainder of the building,

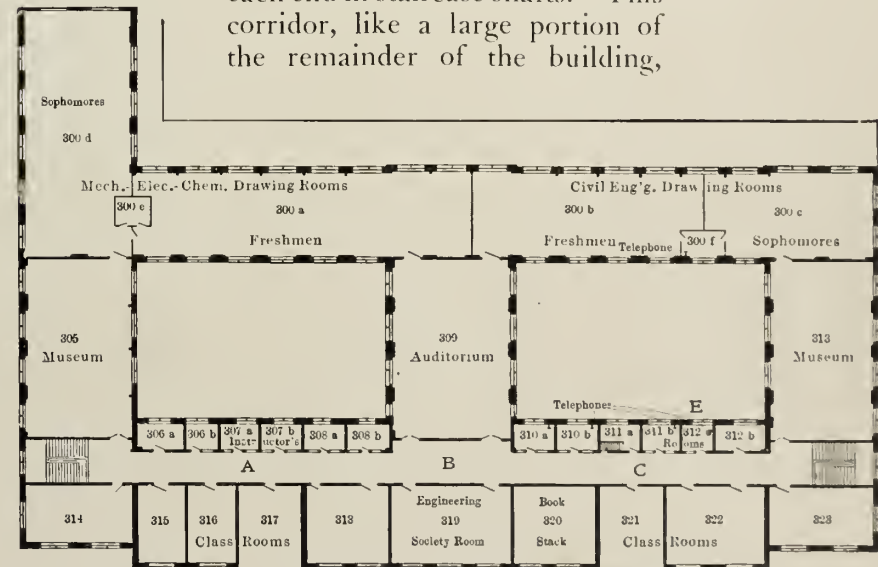


Fig. 5.—Third Floor Plan.

is wainscoted in light-colored marble and presents a very handsome appearance. The middle of the

and some of their assistants. The rooms in the front corners are laboratories, and back of the

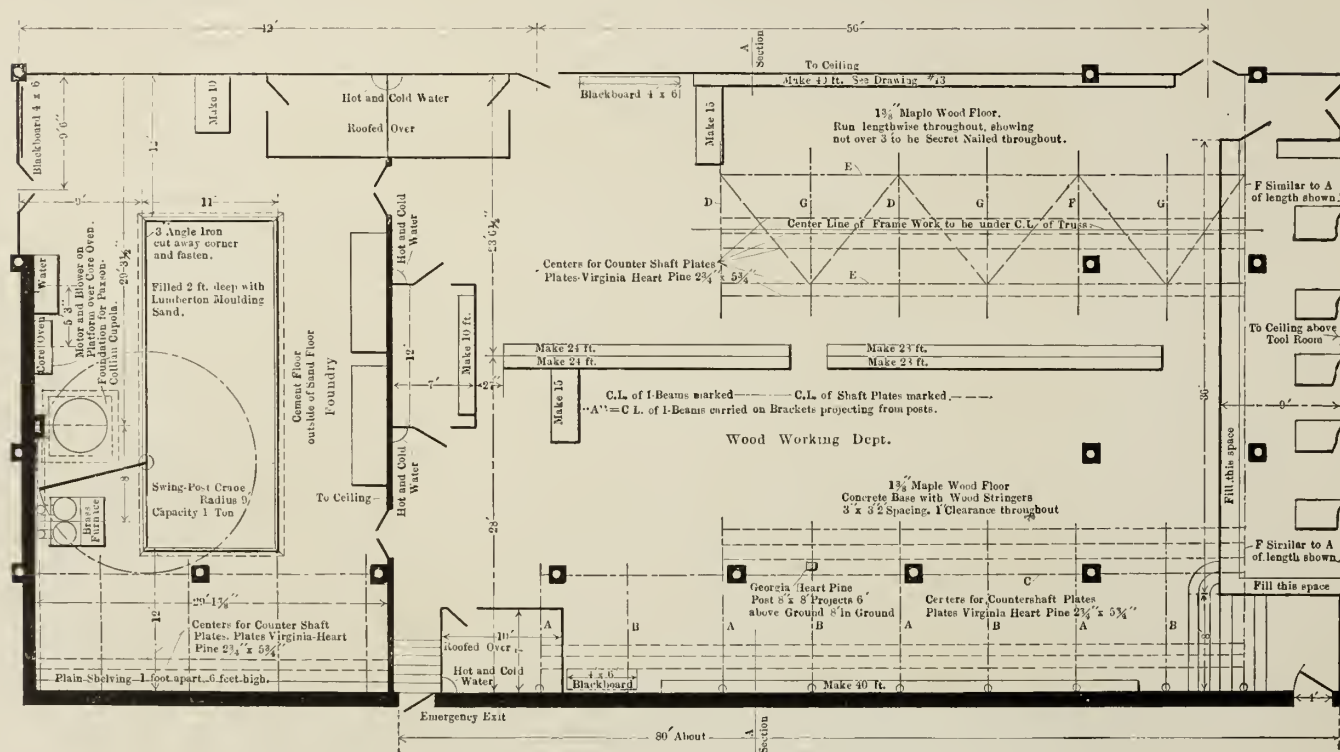


Fig. 6.—Floor Plan of Shops, West End—Foundry and Wood-Working Department.

front or south side of the building is occupied by offices for the heads of the engineering departments

corridor, that is, north of it, but on a level about four feet lower, are the shops and most of the prin-

cial laboratories. The portion of the building along the east wall is occupied by the physical testing and hydraulic laboratories of the civil-engineering department.

By looking at the plans of the upper floors, Figs. 4 and 5, it will be seen that the greater portion of the middle part of the building above the first floor is occupied by two large light wells. The bottom of these is formed by a glass roof over the shops below (and part of the laboratories) which in spite of their position in the interior of the building are, therefore, very well lighted. This portion of the building will now be described in detail.

THE SHOPS

The shops are used in the departments of mechanical, electrical and chemical engineering and consist of a foundry, a wood-working and pattern shop, a machine shop, and a smith shop. The students in the civil-engineering course do not take shop work.

The shops cover about 12,000 square feet of space on the ground floor, which includes, besides the shops mentioned, six offices for the instructors, and a large tool room in the center between the wood-working and iron-working shops.



Fig. 7.—Wood-Working Shop.

THE FOUNDRY

Fig. 6 is a plan of the west end of the shops and shows the foundry and wood-working department. The foundry contains a 22-inch Colliau cupola and a brass furnace, with a one-ton jib crane alongside of the cupola and covering the floor; there are 10 molding troughs, tumbler, core-making machines, and sand sifters, core oven, pickling vat and other foundry appurtenance.

WOOD-WORKING SHOP

Fig. 7 is a view in this department. The wood shop is equipped with 15 benches, ten 12-inch turning lathes and several wood-working machines. The pattern shop contains 15 work benches and 8 turning lathes of various sizes and makes, two band saws, a large tilting-table jig saw, a jointer, surface planer, combination circular rip and cross-cut saw, universal sanding machine, trimmers, tool grinder, glue heater, etc. The line shafting is driven by a 15 horse-power motor.

MACHINE SHOP

Fig. 8 is a plan of the east end of the shops, showing the iron-working, machine, and blacksmith shops, and Fig. 9 is a photographic view in this department. The beginners' iron-working shop contains a 15 horse-power Weston steam engine to drive the line shafting: the shop con-

tains 8 benches, with 16 vises, seven 12-inch by 5-foot speed lathes, two 11-inch by 5-foot engine lathes, four 12-inch by 5-foot engine lathes, one 14-inch by 4-foot spinning lathe, two 20-inch drill presses, a power hack saw and emery wet-tool grinder.

What is known as the machine shop proper, in which the more advanced students work, contains two work benches with four vises, one 30-inch drill press, one 12-inch sensitive drill press, one Universal cutter grinder, Universal lathe- and planer-tool grinder, twist-drill grinder and emery wet tool grinder, three 12-inch by 5-foot speed lathes, four 12-inch by 5-foot engine lathes, two 14-inch by 6-foot quick-change-gear engine lathes, a 30-inch by 12-foot Lodge & Shipley high-speed engine lathe, driven by direct-connected 10 horse-power motor with apron control, a No. 1½ Garvin universal milling machine, a No. 1½ Brown & Sharpe universal milling machine, a No. 1½ Cincinnati universal milling machine, direct driven by a variable-speed motor and having power feed in every direction, a 16-inch Kelley shaper, a 16-inch Walcott motor-driven shaper, a power hack saw, a metal circular saw, an 18-inch by 18-inch by 5-foot Whitcomb planer, a 38-inch by 38-inch by 10-foot Gray spiral-gear planer with three heads and direct driven by a 10 horse-power motor, a Warner & Swasey screw machine, and an iron erecting floor served by a jib crane and piped for

kept in the tool room already referred to, a regular check system being in use. Fig. 10 shows a standard tool case, and Fig. 11 standard chuck and face-plate case. There are 4 tool cabinets, each containing 80 drawers, and to each student is assigned a set of bench tools.

A slotter, Gisholt turret lathe, and Bliss press will soon be installed. Fig. 12 shows the standard machine-shop bench.

THE FORGE SHOP

The forge shop contains 9 Buffalo down-draft forges and a large forge which serves a 250-

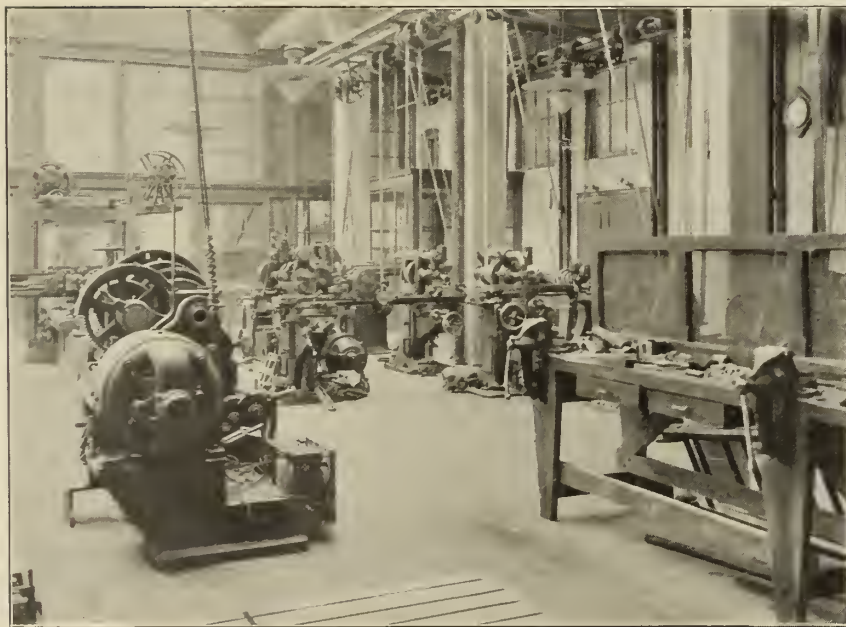


Fig. 9.—Iron-Working Shop.

pound steam hammer visible in the center of Fig. 13; the blast fan is direct driven by a 5 horse-power motor, and another motor of the same size drives the exhaust fan. There are nine 100-pound anvils, a drill press, emery grinder, power punching machine, pipe machine, and various other appliances. There is still another 5 horse-power motor to run the line shafting.

The shops collectively will accommodate about 90 men working at the same time.

METHOD OF INSTRUCTION IN THE SHOPS

One of the principles followed in this institution is to give each student as much individual attention as possible. Toward this end the classes are divided into small groups so that an instructor will not have more than say 10 men at once, and is therefore enabled to watch closely the work of each man, and give him such assistance as he may need. In the shop work each man gets his own particular job to do, and is required to use his own brains as much as possible in finding out how to do it, although, of course, the instructor is ready to point out defects in his methods. It is well to mention here that the *educational* idea is paramount, very little consideration being given to the idea of building machines for use or for sale. Because of the

vast amount of information which there is to acquire in the business, and the comparatively very

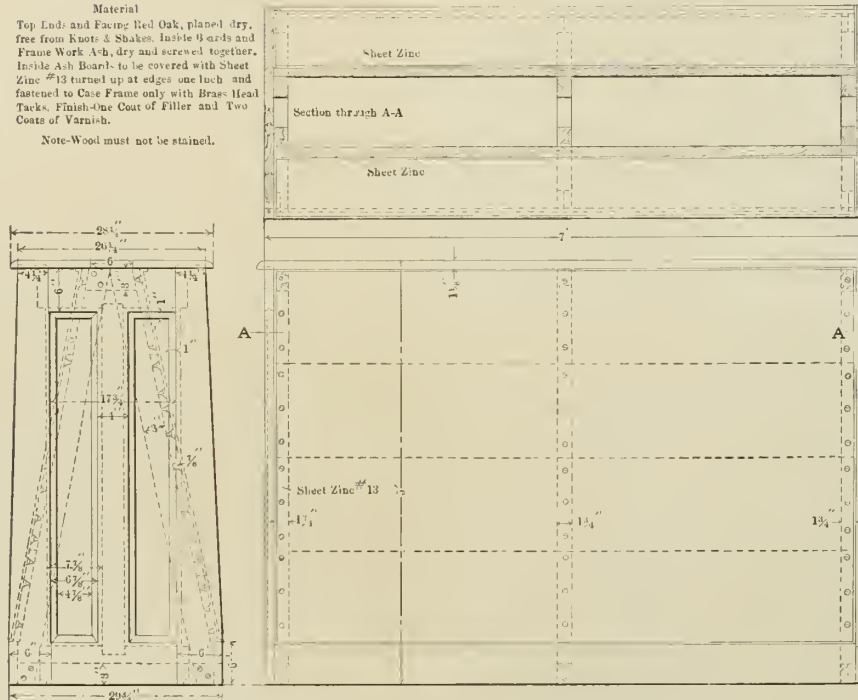


Fig. 11.—Standard Chuck and Face-Plate Case.

brief period in which the student has to work at acquiring it, it is very important that the highest educational efficiency should be aimed at all the

time. If a student can attain a certain amount of manual dexterity, it is well and good; the central idea, however, is for him to acquire the habit of thinking, and to thoroughly understand the various processes, and he cannot therefore afford to spend time in repetition after he has once mastered any particular job. There is a certain time limit allowed to each operation, and if the student takes more than that time to perform it, he is conditioned. Of course he gets credit if he does better than the maximum time allowed. There is also a standard of workmanship, and if the work is not up to the standard, it is rejected. The exercises are very largely machine parts; during the second term one of the machines in the laboratories or shop is

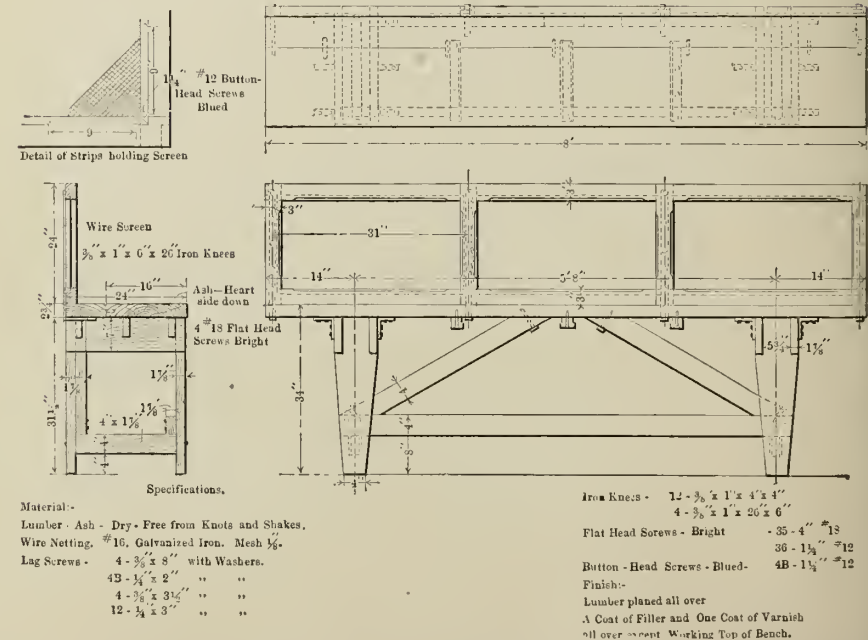


Fig. 12.—Standard Machine-Shop Bench.

turned over to the sophomores, and they take it apart and make sketches of its different elements, and by the end of the first term in the junior year they have made working drawings and traced them, and these go into the shop to be used to construct pieces from. If enough pieces are made to make a complete machine, it is assembled. The order of the student's work, however, is not interrupted for the sake of making a show-piece, nor is the practice followed of having certain parts of a machine, for instance, heavy castings, made outside and then completing the machine and regarding it as the product of the college shop. A pamphlet has been gotten up by J. J. Morris, superintendent of shops, setting forth all the jobs to be done and to each one is a list of references to text-books, the *AMERICAN MACHINIST* and other journals, in which information on this kind of work can be found. Some time before the shop period in which a particular job is to be done, the student is notified of his assignment, so that he has a chance to read up his references and get a good theoretical knowledge of the work before he actually tackles it. He is required to make notes and turn them in for inspection. A very complete time-card system is in use, which enables the professor in charge to have on file a full record of the work of each student.

THE LABORATORIES OF THE MECHANICAL ENGINEERING DEPARTMENT

The total floor space devoted to mechanical-laboratory purposes is 14,000 square feet. The mechanical laboratory is at the back of the building, north of the shop, and occupies also the north-west corner, taking up a space of 183 feet east and west, by 64 feet, with an L 40 feet by 38 feet, pointing to the north.

The steam, exhaust and water piping is run overhead, steam at 100 pounds pressure being supplied from the central light and heat station of



Fig. 13.—Forge Shop.

the University. The electric current is carried throughout the laboratory so as to afford convenient power outlets for various motor drives. The laboratories, like the shops and other large rooms in the building, are lighted at night by enclosed arc lamps with diffuser shades, which give a brilliant illumination without being dazzling. Starting at the northwest corner of the building we find there a Roberts water-tube boiler of 100 horsepower, capable of carrying a pressure of 250 pounds per square inch. This boiler will supply either saturated or superheated steam for special

experimental purposes, and alongside of it is a small erecting floor, upon which any kind of machine which it is desired to test may be mounted and connected up. South of the erecting floor are a few small apartments, one of which contains a ventilating and heating plant, consisting of blast fan and steam coil, and another of these rooms contains a complete refrigerating and ice-making plant, having a one-ton ammonia machine. Alongside of the wing of the building is a small lean-to, containing a cooling tower, and in which it is intended to also place a suction gas producer.

Inside of the laboratory in the neighborhood of the lean-to are a number of gas engines, to be run on city gas. This includes a 3 horse-power Warren engine, a 10 horse-power Springfield engine, a 30 horse-power two cylinder vertical Westinghouse, and a 15 horse-power Burger. It is intended to install another one to be run directly from the suction gas producer.

Along the north wall of the building is what is called the steam laboratory, shown in Fig. 14, and consisting of a long line of steam engines, condensers, injectors, etc. The first one (not shown in the picture) is a small DeLaval steam turbine; beyond that is a Reeves vertical compound engine arranged for steam consumption tests, with a Wheeler surface condenser, and beyond

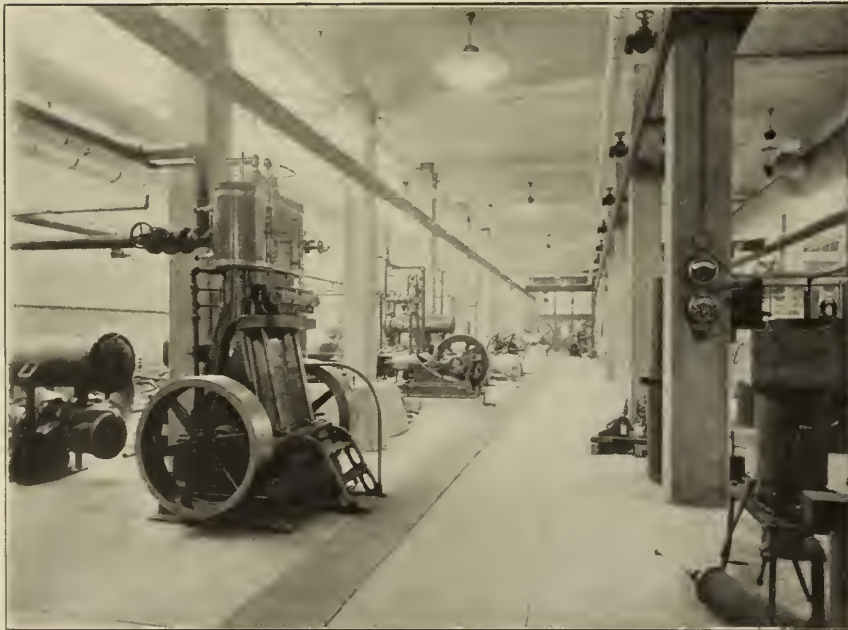


Fig. 14.—The Steam Laboratory.

that is a Buckeye engine similarly arranged (but which was not on its foundation when the picture was taken). An Ingersoll two-stage steam-driven air compressor of a capacity of 150 cubic feet of free air per minute is connected to a pair of receivers so that the air discharged can be measured continuously. Beyond this is a Harrisburghigh-speed engine, next a steam pump and jet condenser and a Porter-Allen engine, an Ames engine, and a 10 x 24 inch Hamilton-Corliss, which, together with a Fairbanks slide-valve engine, is used for valve setting. Along the wall are several injectors, a pulsometer and an indicator tester. Near the eastern end of the room

is a two-stage belt-driven air compressor, and an air blower.

The southeast corner of the room is occupied by the material-testing laboratory, Fig. 15, which contains two 30,000 pound Riehlé tension machines, one 30,000-pound and one 50,000-pound Olsen tension machine, a 60,000 inch-pound Riehlé torsion machine and a Thurston torsion machine. The tension machines and the Riehlé torsion machine are each motor driven with the speed

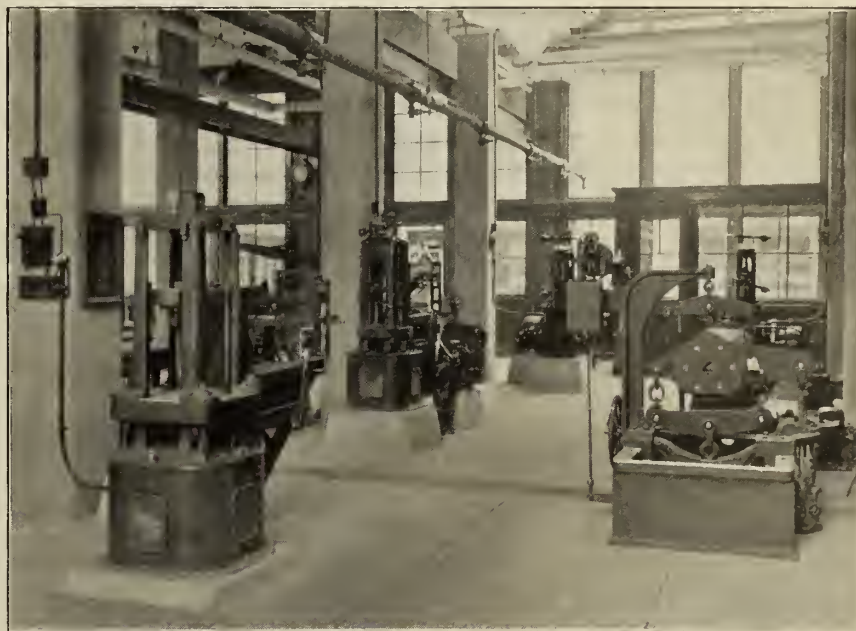


Fig. 15.—Material Testing Laboratory.

control directly at the machine.

Along about the middle of the south side of the large room is a dynamometer laboratory. This contains a Webber dynamometer, a Flather

dynamometer and a Thurston railroad-oil tester, these machines being belt driven from a shaft driven by electric motor. A rope drive arranged for testing purposes is also being installed here.

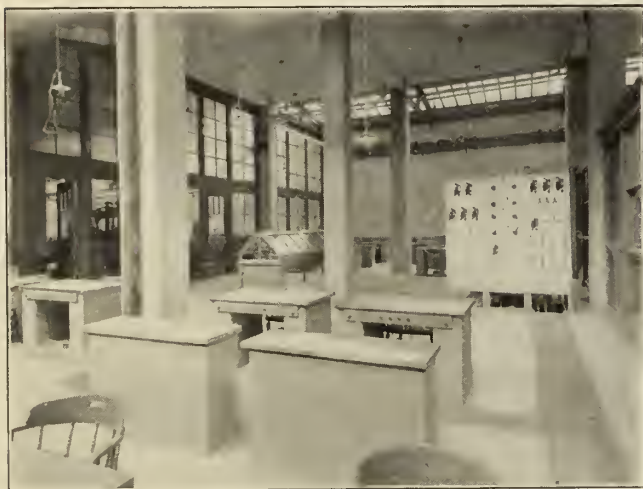


Fig. 16.—Electrical Instrument Laboratory.

There is an instrument room with all needed arrangements for taking care of and handling the small pieces of apparatus.

The southwest corner of the room is occupied by the hydraulic department, which contains various pressure and receiving tanks, scales and pieces of apparatus for tests, including arrangements for testing gas meters, two Venturi meters,

a 2-inch centrifugal pump, a Doble impulse wheel, a Pelton wheel and a Leffell reaction wheel; a hydraulic ram is supplied from a tank suspended from the ceiling. There is a seven-inch Morris centrifugal pump driven by a 30 horse-power motor, subject to float control, which takes the water from the cold-water cistern on one side of the hydraulic laboratory and pumps it into the 22,000-



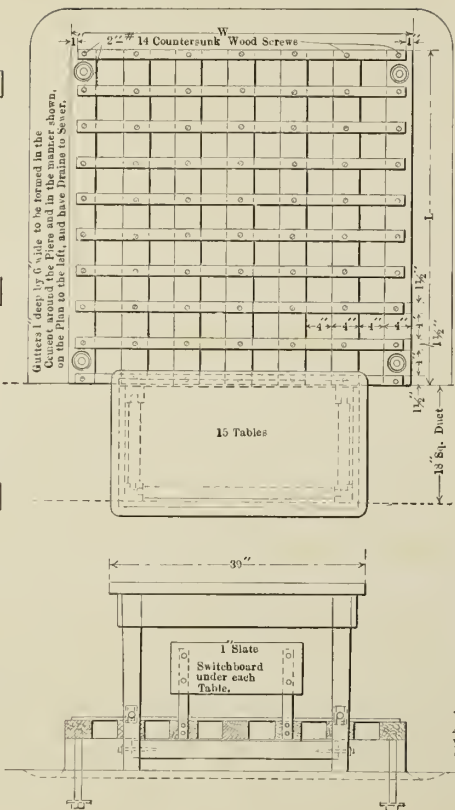
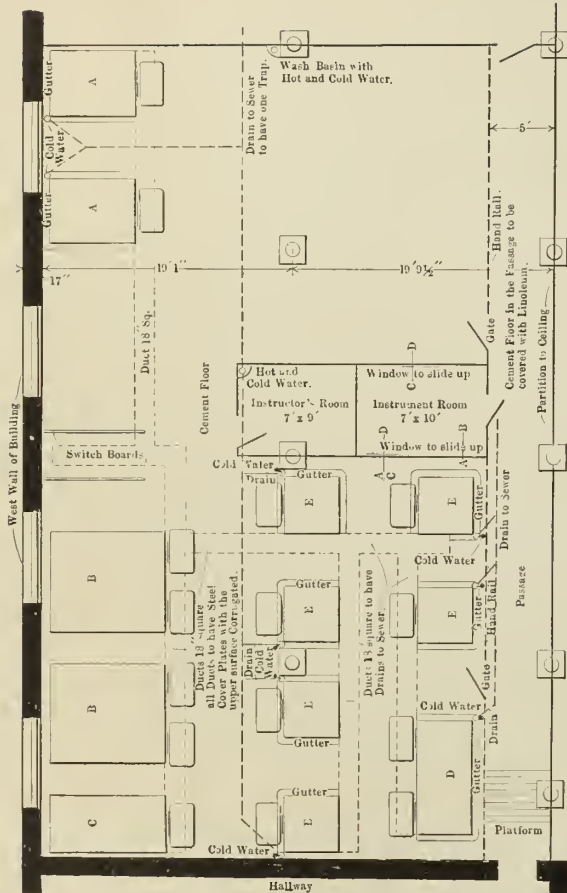
Fig. 17.—Direct-Current Dynamo Laboratory.

gallon storage tank in the attic. There are also two Ericsson hot-air pumping engines and a motor-driven triplex pump.

In connection with the mechanical laboratory

Dynamo and Motor Foundations

Floor Plan



Dynamo and Motor Foundations			
Position	Length L	Width W	Number Required
A	6'6 $\frac{1}{2}$ "	5'0"	2
B	8'10"	7'8"	2
C	8'10"	4'4"	1
D	4'3"	9'0"	1
E	4'3"	4'4"	6

All Foundations to be made of the same Materials,
Yellow Pine Wood and Black Wrought Iron Bars.
The Units in all cases to be of the same size and spacing.
The length and width of the Foundations and number
of Units to vary.

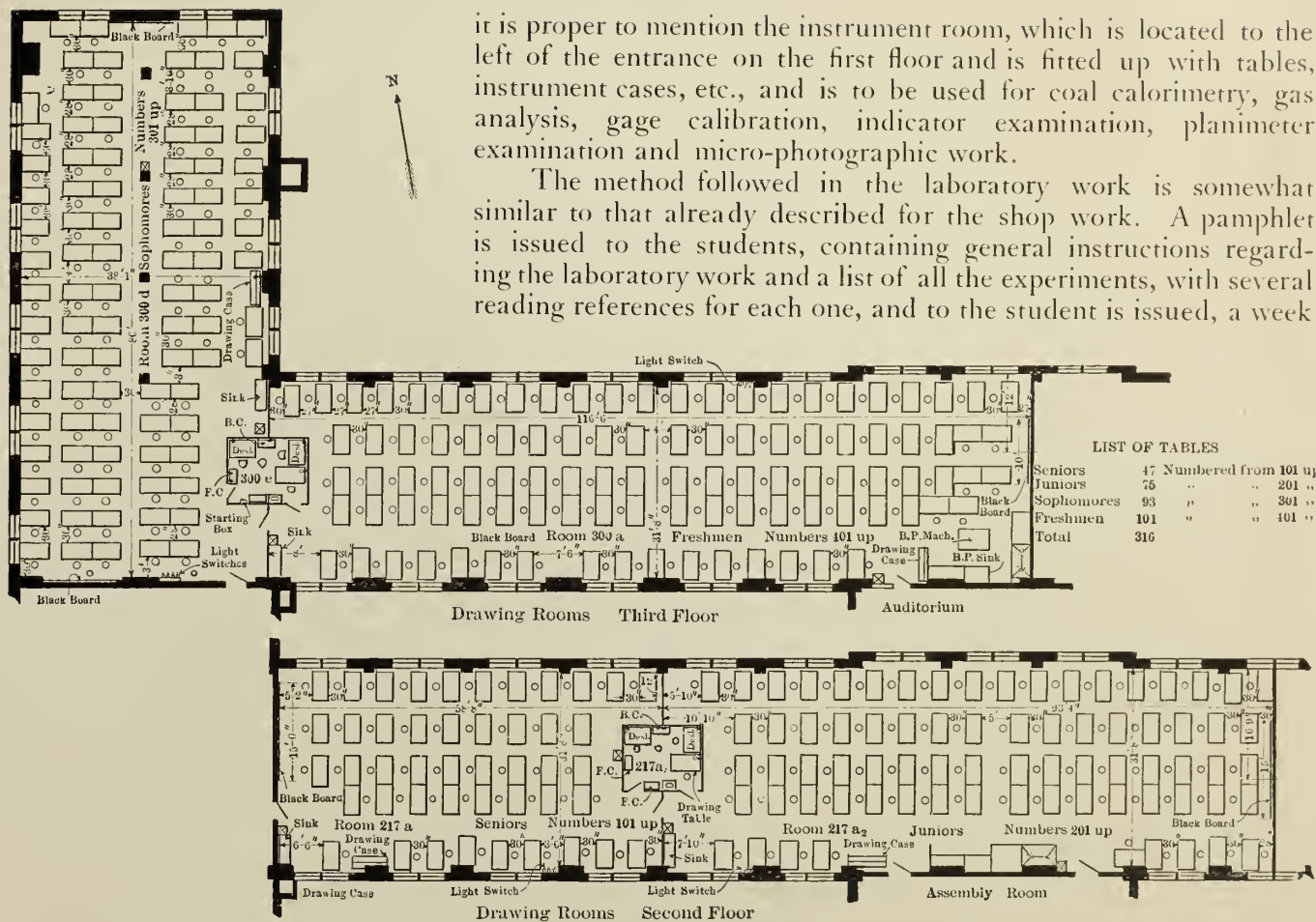


Fig. 20.—Plan of Drawing Rooms and Instrumental Offices, Mechanical Engineering Department.

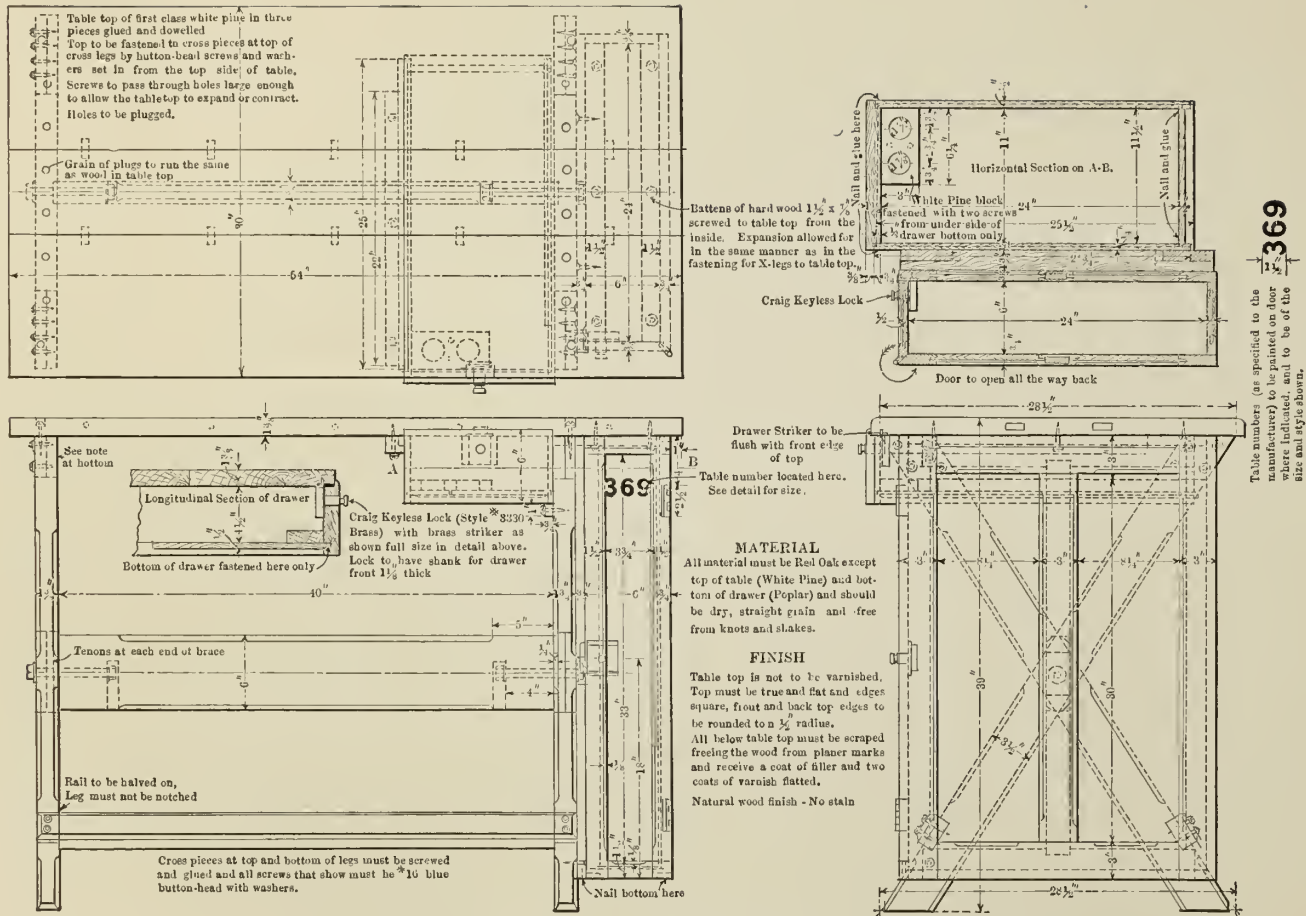


Fig. 21.—Standard Drawing Table, Mechanical Engineering Department.

before he is to perform a given experiment, a report cover with instructions as to the conditions, etc., and during this advance time he reads up his references, and after making the experiment he turns in a full and complete report in the cover. The students work alone as much as possible, although, of course, on some experiments more than one observer is required. There is an instructor to about every eight students.

THE ELECTRICAL INSTRUMENT LABORATORIES

The instrument laboratory, Fig. 16, which is next east of the mechanical laboratory, is the one in which the electrical students first meet with their practical electrical work. In it are made experiments in the measurement of electromotive force, current, resistance, temperature coefficient, thermo-electric effect, inductance, capacity and permeability, the calibration of voltmeters, ammeters and wattmeters (indicating and integrating) and the determination of galvanometer constants. The floor space in this laboratory is over 4500 square feet, part of it being inclosed to form an apparatus room. Like the shops and mechanical laboratory it is largely under skylight. It contains also three instructors' offices and a small storage-battery room, so located as to divide the laboratory into eastern and western halves, assigned to the juniors and seniors, respectively,

and each of these parts is again divided into sections, which permit of two separate lots of

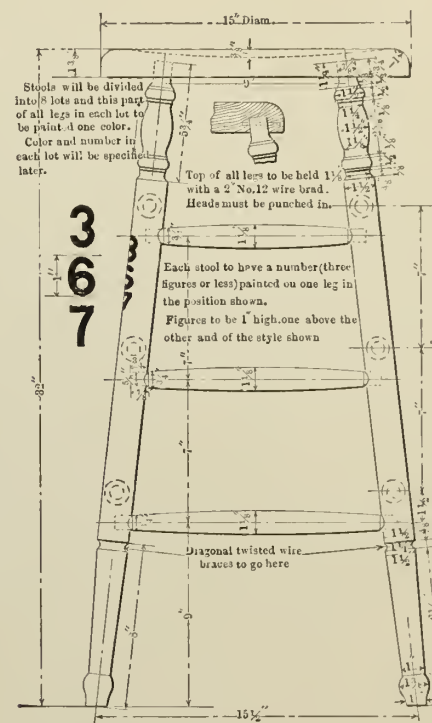


Fig. 22.—Standard Stool for Drawing Room.

students of the same class working at once, if found convenient. On the junior or eastern side there are accommodations for 24 men, and on the senior or

western side, accommodations for 18 men. For each student there is a table and a galvanometer pedestal, which can be seen in Fig. 16, and which are shown in detail in Fig. 18. The former consists of two concrete columns, each about two



Fig. 23.—Foundry.

feet high, carrying a slate slab 26 x 44 inches and $1\frac{1}{2}$ inches thick; a little distance away from the table is a galvanometer pedestal which consists of one solid concrete column, with a slab 15 x 44 inches and $1\frac{1}{2}$ inches thick, the pedestal being the same height as the table. By providing these

solid supports for the instruments, vibration is practically done away with. Each of the groups both on junior and senior sides, is provided with its own switchboard (one is seen in Fig. 16) and its own storage-battery installation, the four

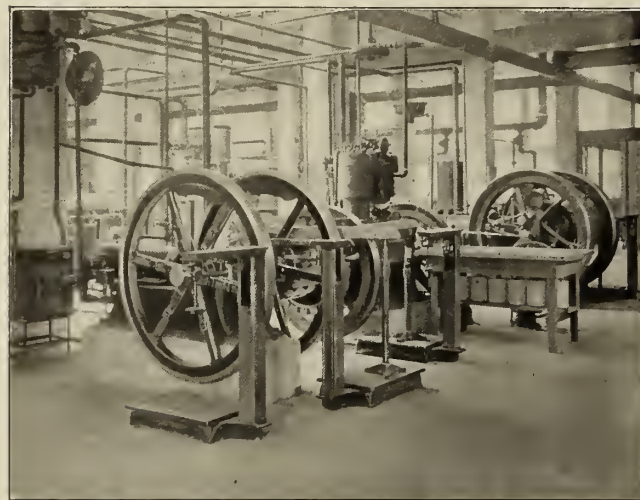


Fig. 24.—A Corner in the Mechanical Laboratory.
The Gas Engines.

switchboards being of white Italian marble like all the switchboards in the electrical laboratories. The wiring in this room is rubber covered and is run under the floor in easily accessible ducts; it is so arranged that any table can draw current from any source of supply.

The storage-battery equipment in connection with this laboratory contains, to each switchboard, 80 General Storage Battery Company cells, each of which has a capacity of three amperes for eight hours; they are so arranged that any combination can be obtained by means of dial switches on the switchboard. There are, moreover, to the senior boards, 18 Westinghouse cells capable of supplying 15 amperes each for eight hours, intended for purposes where a large current and low electromotive force is required, the other cells being used where high potential and low current strength are needed. The junior boards each have six of these cells. As there are four switchboards there is a total of 320 of the small cells and 48 of the large cells, 36 of the latter being for the two senior switchboards and 12 for the two junior switchboards. Each senior switchboard has connected with it a two-kilowatt alternator.

The apparatus room contains about 45 galvanometers, about 60 different standard resistance boxes, ranging in resistance from $\frac{1}{10}$ ohm to 1 megohm, 18 standard condensers, alternating- and direct-current integrating wattmeters, galvanometer shunts, etc.

This laboratory contains a complete quadruplex telegraph equipment on the Western Union system, to enable students to become acquainted with the construction and care of the apparatus. Its case with sloping glass top is visible in Fig. 16.

The room at the southwest corner of the building, on the main floor, will form what might be called the "local bureau of standards," in which all standardizing work for electromotive force, resistance, capacity, inductance and electrical quantities and instruments in general can be done.

THE DIRECT-CURRENT DYNAMO LABORATORY

This room is at the west end of the building, on the first floor, and has a floor space of over 2000 square feet, being 33 feet by 62 feet, and it includes an instrument room and instructor's office. The wiring is installed in a manner similar to that in the laboratory already described, the wires being fire and weather proof, not rubber covered. Fig. 17 is a photographic view in this room, and Fig. 19 is a floor plan, which also shows the raised concrete foundations provided for mounting the dynamos and motors used in the tests. There are twelve of these testing beds of different sizes. It will be seen that the concrete bases are surmounted by wooden runners of yellow pine, upon which at right angles are placed iron straps. The straps are screwed to the wood, and the wood is bolted to the concrete. The machine rests upon the iron straps, and by a simple device may be clamped in any desired location, the straps of flat iron acting as abutments to resist the pull of the

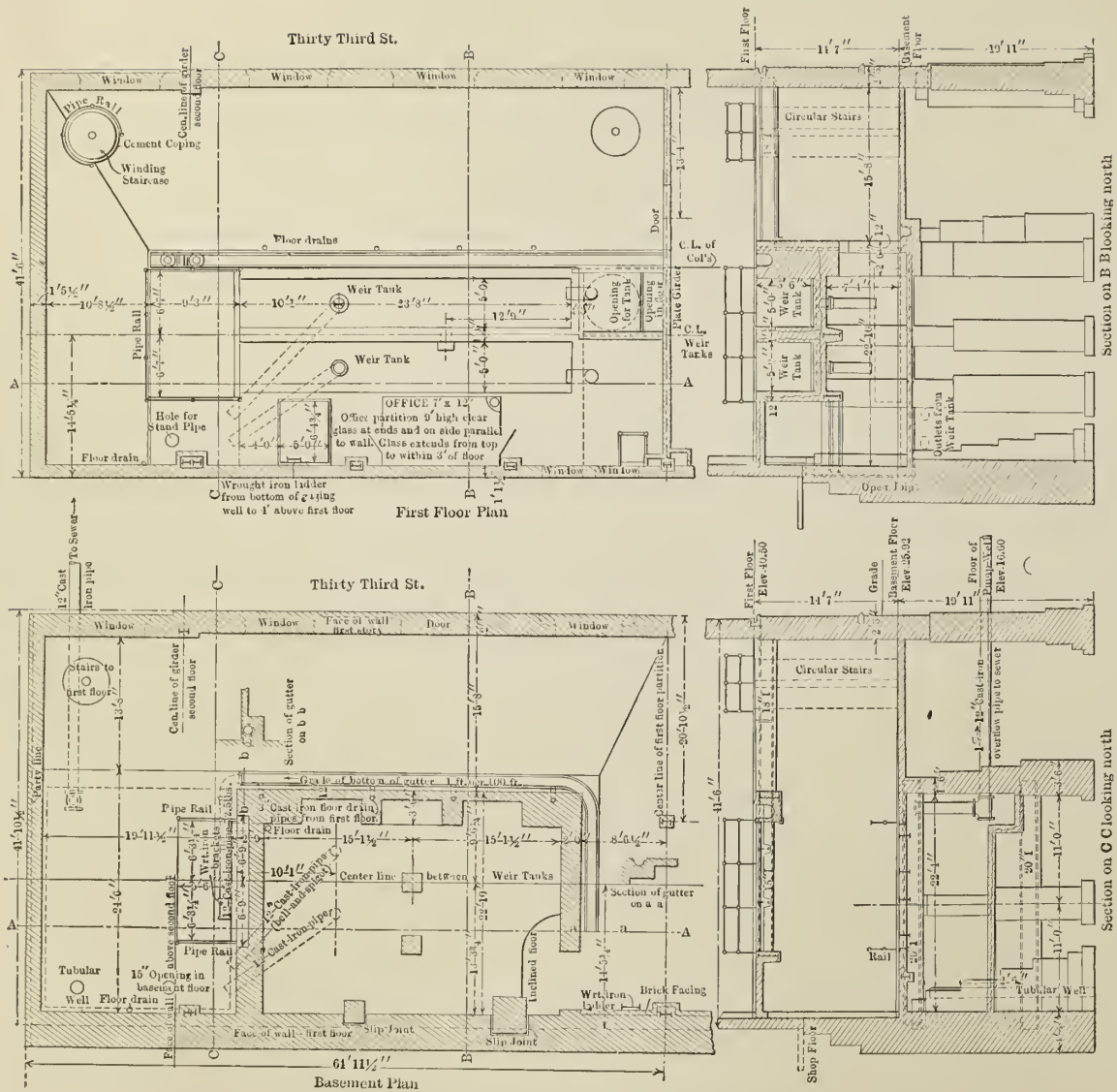


Fig. 25.—Hydraulic Laboratory, General Drawing.

belt. The wood serves to absorb the vibration produced by the machines. At each testing bed

vibration from the machine. As previously stated, the main power supply is direct current at a

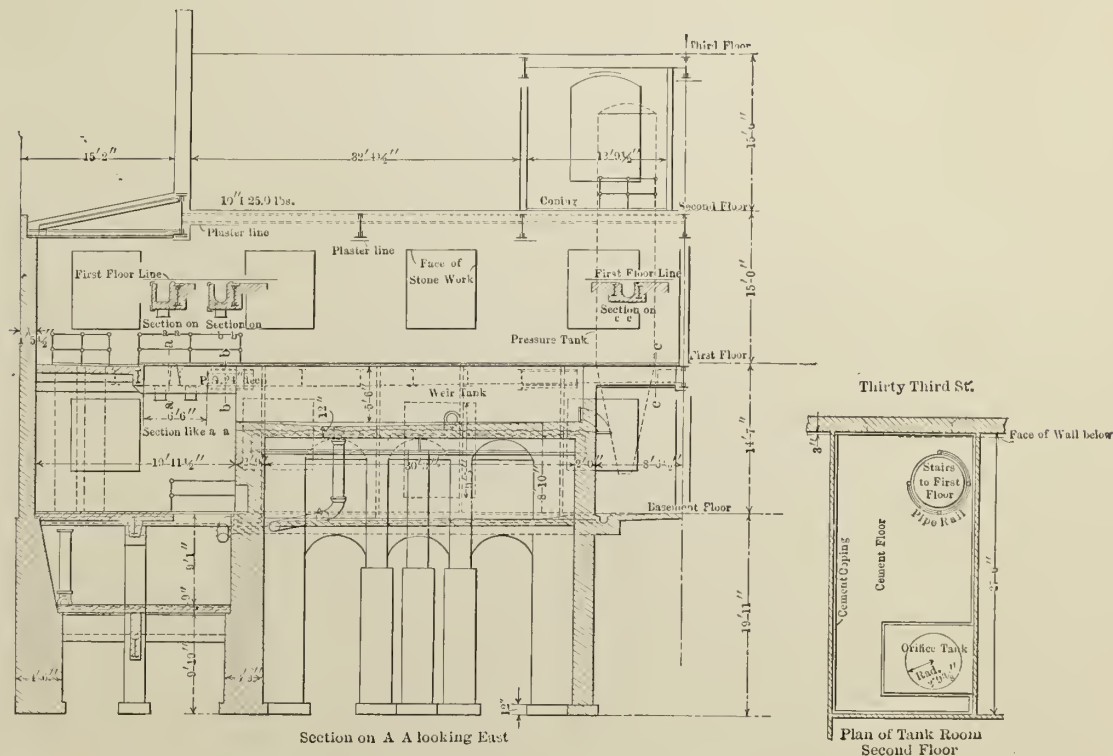


Fig. 25 (Continued).—Hydraulic Laboratory, General Drawing.

there is provided a table and terminal board, the table being attached to the concrete to avoid

potential of 110 volts, being supplied by the generators in the building.

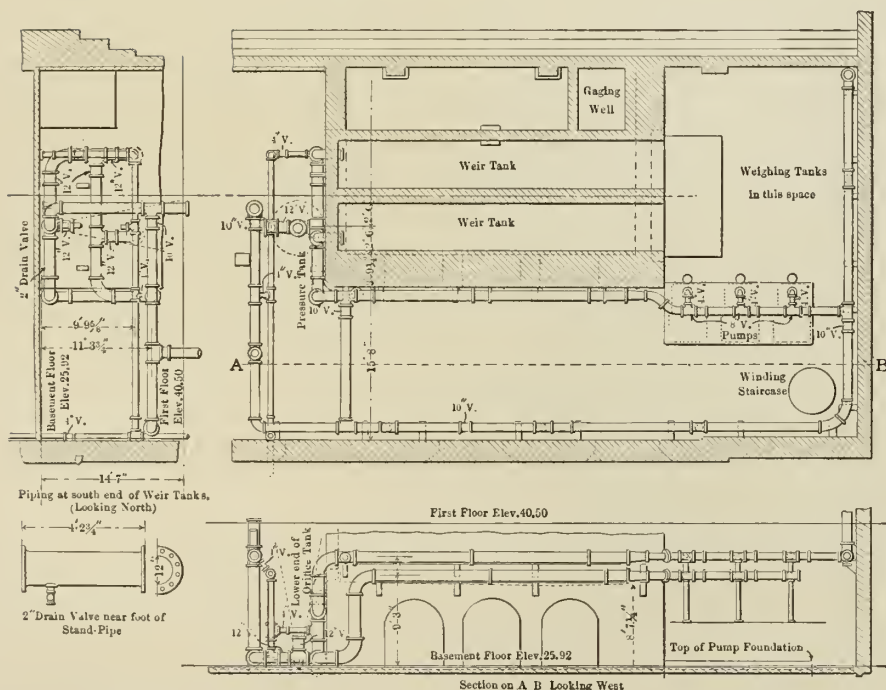
THE SECOND FLOOR—ALTERNATING-CURRENT LABORATORY

The room in the northwest corner of the second floor (see Fig. 4) is the alternating-current laboratory. It has a total floor space of over 2100 square feet (38 feet by 56 feet) and includes also instrument room, instructor's office, and the photometer rooms. This laboratory, like the direct-current laboratory on the first floor, already described, contains a number of testing beds, upon which the motors and generators may be mounted. There are six testing beds of different sizes holding from

one to three machines on each. The wiring is overhead. The only direct-current machinery in this laboratory is that used for driving the generators. There is available at all parts of the laboratory current from the storage battery in the basement, the possible electromotive force of which varies from 6 volts to 150 volts. The purpose of this is, for instance, separate excitation where a very uniform current is desired. The 6-volt battery current can be supplied up to 180 amperes, and the 150-volt up to 15 amperes.

The switchboard in this room is the largest one in the building for laboratory purposes; it is over 14 feet in length and contains seven marble panels, all circuits being protected by I. T. E. circuit-breakers. The alternating-current circuit of each test is entirely separate and distinct from that of all the other tests, the source of supply being an alternator driven by a direct-current motor for that purpose alone. There is, therefore, no interference whatever between the different tests. At each testing bed there is located a rheostat for the generator supplying the machine under test, so that the man at the testing bed can readily control his electromotive force, and he has practically an isolated plant under his direction.

In this laboratory are made tests on single-phase, two-phase and three-phase generators and motors, arc lamps, experiments on transformers, the effect of capacity and reactance in different



arrangements of series and multiple. There is a full supply of synchronous and induction motors and generators for tests, all prominent makers being represented. There are seven alternating-current motors, and there is other apparatus in much variety, such as two or three wave-form machines, one of which is a Rosa curve tracer. There are about 100 voltmeters, ammeters and wattmeters provided for this laboratory, the number allotted to each experiment being ample for the rapid and accurate carrying on of the test. There are, moreover, potential transformers, current transformers, frequency indicators, synchronizers, power-factor indicators, arc lamps, including Adams-Bagnall and General Electric, both alternating current and direct current. All portable apparatus is stored away in cabinets in the instrument room.

THE PHOTOMETER ROOM

At the southern end of the alternating-current laboratory are two photometer rooms, one equipped with a Bunsen photometer and the other with a Lummer-Brodhun, made by the Leeds & Northrup Company, each of which has a three-meter track. A "labyrinthic" entrance insures darkness; ducts and electric fans provide ventilation.

THE STORAGE-BATTERY ROOM IN THE BASEMENT

In connection with the electrical laboratory it is proper to speak of the storage-battery installation, which when finished will supply current to the direct- and alternating-current laboratories, and will contain 16 General Storage Battery

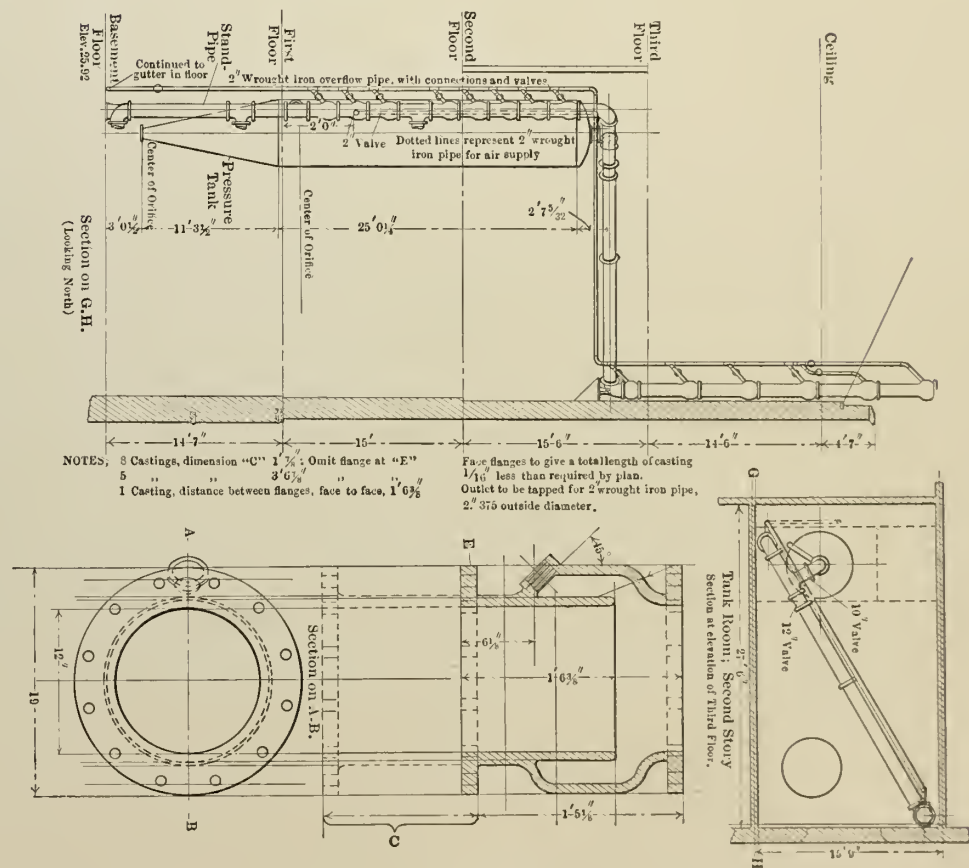


Fig. 27.—Stand-pipe and Pressure Tank.

Company cells, capable of supplying 15 amperes for eight hours, or 60 amperes for one hour; and 66 Electric Storage Battery Company cells, capable of supplying $4\frac{1}{2}$ amperes for eight hours, or 18 amperes for one hour. This room is located

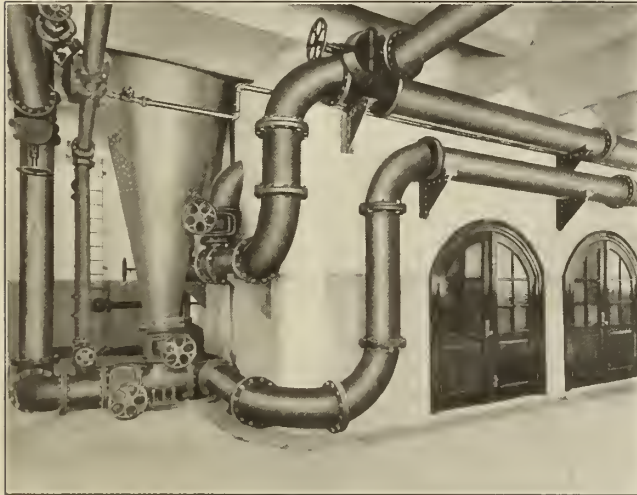


Fig. 28.—Conical Bottom Section of Pressure Tank; Stand-Pipe and Piping System, and Basement of Hydraulic Laboratory.

in the basement at the southwest corner of the building (Fig. 2).

THE REPAIR SHOP ON THE SECOND FLOOR

The room next south of the alternating-cur-

rent laboratory on the second floor is a repair shop, containing a complete assortment of machine tools and small tools for making repairs to the apparatus in the laboratories, and for instrument making. This is done by toolmakers employed for

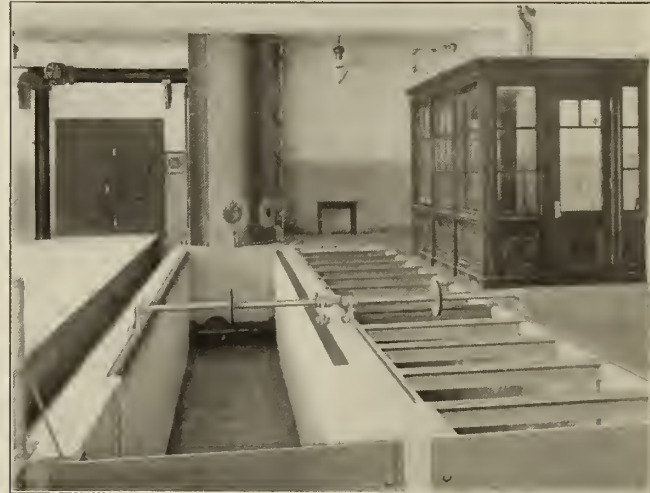


Fig. 29.—Weir Tanks and Pressure Tank. Hydraulic Laboratory, First Floor.

the purpose, although the equipment may be used by students engaged in thesis work, or by students who require some special contrivance for use in laboratory experiments. There are about 900 square feet of floor space in the room.

JUNIOR AND SENIOR DRAWING ROOMS

The back portion of the second floor is occupied by the drawing rooms for the juniors and seniors (see Fig. 20), the eastern portion being for the juniors, and the western portion for the seniors; we are not now considering the civil-engineering department drawing rooms, which are in line with the former at the other end of the building. The equipment of these rooms is similar to that of the rooms for the freshmen and sophomores on the floor above, which will be described later.

ASSEMBLY ROOM, LIBRARY, ETC.

In the middle of the building on this floor is the assembly room, or "students' relaxation room," which will be fitted up comfortably for the students to use in their leisure moments.

The middle room in the front, or south of the building is the library, and above it on the third floor is a book stack communicating with the library by a winding staircase. The library and stack will hold about 20,000 volumes.

Along the front of the building on each side of the library are several recitation and lecture rooms which are continued around on the end of the building on this floor. Across the corridor on the south side of the light-wells are several rooms for the instructors.

THE THIRD FLOOR

The allotment of the space on this floor is sufficiently indicated on the plan, Fig. 5, it being only necessary to give details of the freshman and sophomore drawing rooms, which occupy the back portion.

THE FRESHMAN AND SOPHOMORE DRAWING ROOMS

The drawing rooms are shown in plan in Fig. 20. The room at the northwest corner, extending north and south, is the sophomore drawing room and is 86 feet long by 37 feet wide, and next east of it is the freshman drawing room, which is 117 feet long by 32 feet wide. The ceilings are 14 feet high. These drawing rooms, like the ones on the floor below and the laboratories, are illuminated by G. E. 110-volt 5-ampere enclosed arc lights, with opaque lower globes and concentric diffuser shades, which give an abundance of light, a very uniform distribution, without dazzling or shadow. The freshman room contains 17 arc lights, and the other rooms are in proportion. Each student has assigned to him his own drawing table, there being



Fig. 30.—Stand-Pipe and Upper End of Pressure Tank, Second Floor.

provision for 101 men in the freshman room and 93 in the sophomore. The drawing table and stool assigned to each student for his exclusive use throughout the college year bear the same number, and the locks on the drawer and cabinet are opened by the same combination as his locker in the basement. The standard drawing table and standard stool are shown in Figs. 21 and 22 respectively. Portable drawing boards 32 x 31 inches are used and kept, with the T-square, in the cabinet under

the table when not in use. The numbers are not only painted, but are impressed in intaglio on the articles, so that they cannot be changed, and the stools for any one room all have a color band around them, peculiar to that room, which at once indicates where they belong. The total floor area of the four drawing rooms in this department is 11,800 square feet.

The system of instruction in drawing is thoroughly systematized, and by means of a card index and vertical-filing system a complete record is kept of the work of each student. The first four plates of the freshman year are all alike, being merely copies, and after this the work throughout the course is individual, each man working out his own problems, as assigned by the instructors.

The building is equipped with telephone systems, so that the offices of heads of departments are connected together, and the separate branches of the different departments are also connected by separate lines.

Figs. 23 and 24 are views properly belonging to the previous installment of this article, but the photographs did not come in time. They show the foundry and the gas engines in the mechanical laboratory. These engines,

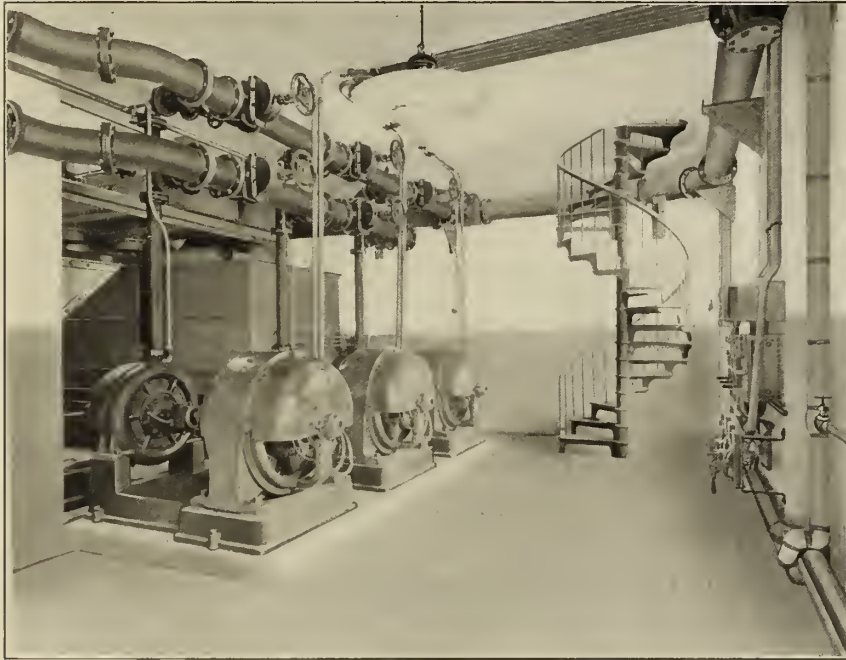


Fig. 31.—Two-Stage Electrically Driven Centrifugal Pumps; Overhead Chute and Weighing Tanks. Basement, Hydraulic Laboratory.

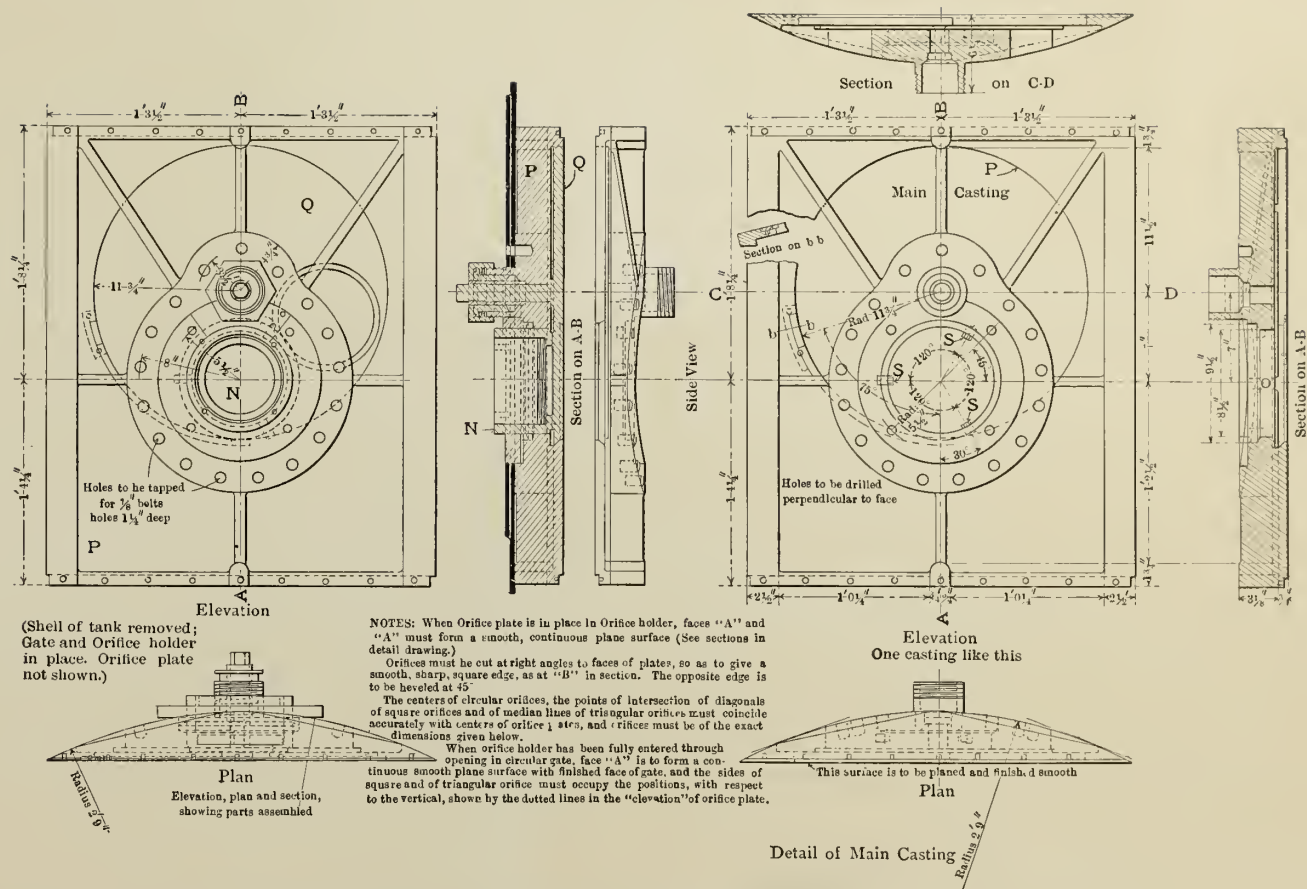


Fig. 32.—Device for Holding Orifices and Changing them with Tank under Pressure.

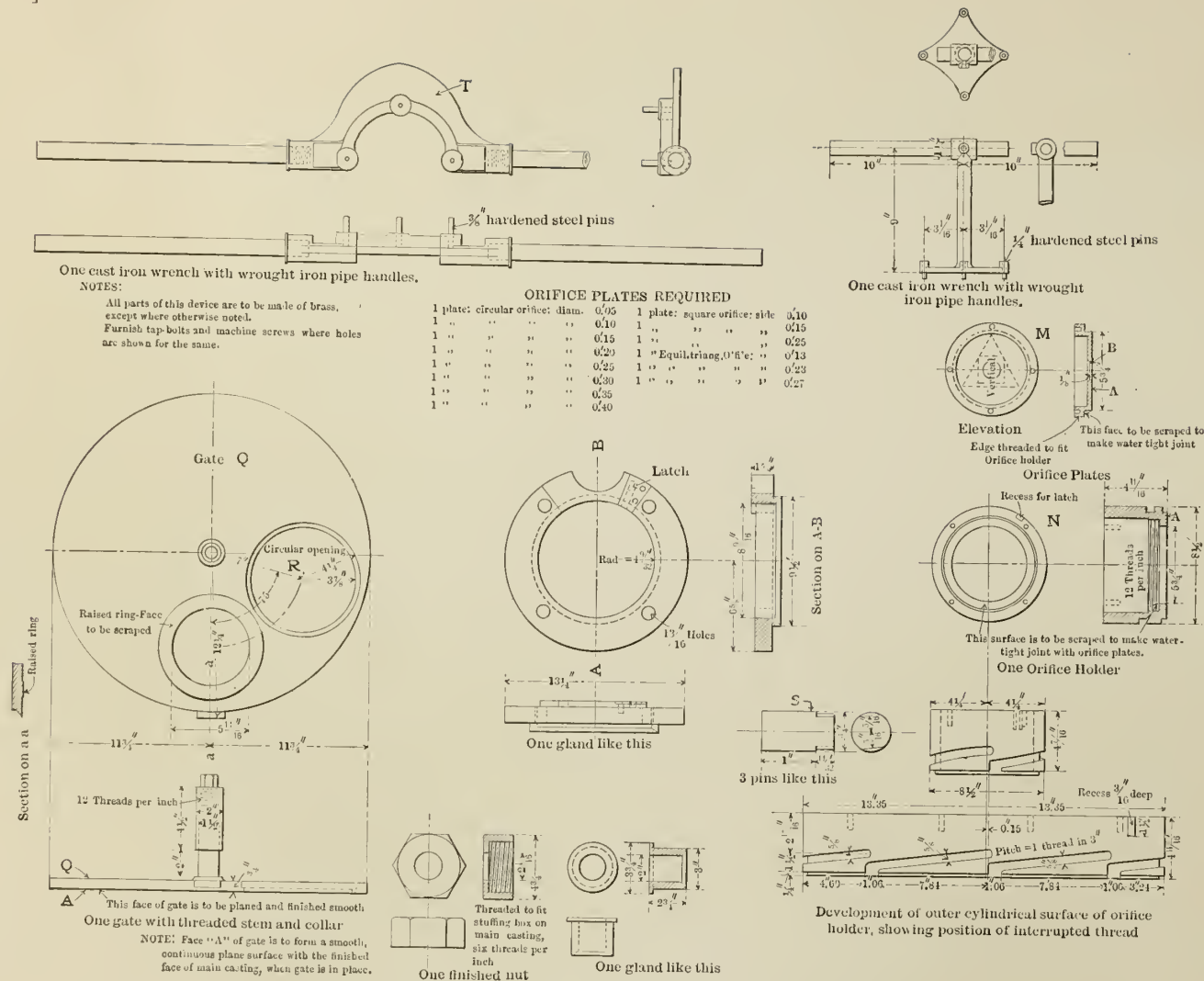


Fig. 33.—Details of Orifices and Device for Holding Them.

like the steam engines and other motive-power machines, are well provided with Prony brakes.

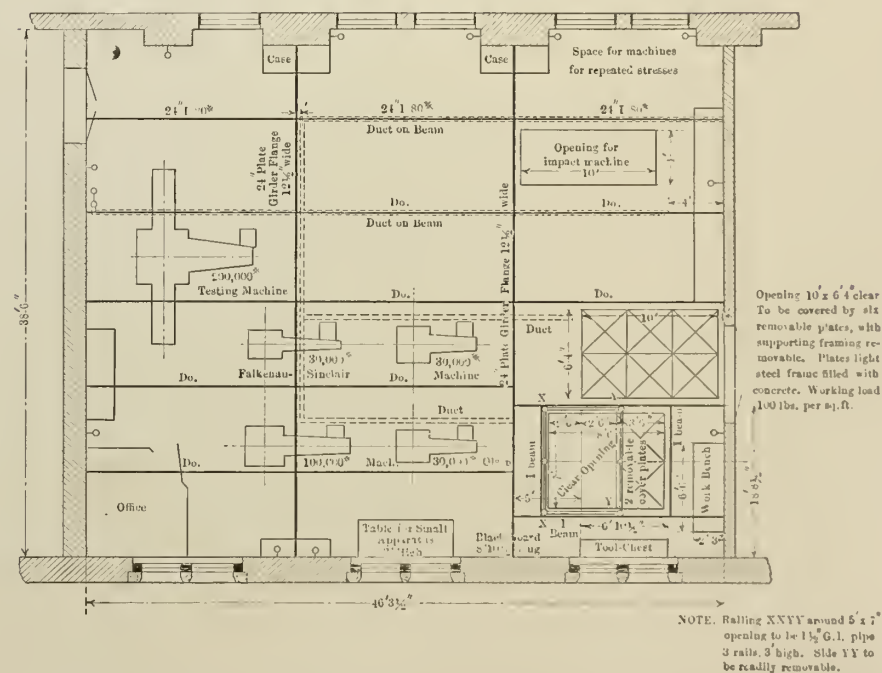
THE CIVIL ENGINEERING DEPARTMENT. A FINE HYDRAULIC LABORATORY

As already stated, the eastern end of the building is occupied by the civil-engineering department. The most prominent feature of this portion is the hydraulic laboratory which occupies the northeast corner, and extends through three floors. The general drawing of it is given in Fig. 25, and some of the details in the basement in Fig. 26. In this laboratory there is a pressure tank $5\frac{1}{2}$ feet in diameter and 37 feet high, of $\frac{3}{8}$ -inch plates, with a total capacity of 5800 gallons, shown in outline in Fig. 27, for the purpose of furnishing water for experiments on the discharge through orifices and tubes, and in connection with it are two calibrated weir tanks $5 \times 5\frac{1}{2}$ feet in cross-section, 34 feet long, with partially removable ends to permit also of observations of flow over submerged weirs and dams. They discharge into two weighing tanks on scales mounted on wheels, each having a capacity of 1800 gallons and arranged with quick-discharge valves for emptying them into the main supply tank underneath, which has a capacity of 23,000 gallons. By having two tanks, it is thus possible to have a continuous discharge. The main supply tank is connected with the city water mains, and also by overflow and drain pipes with

the sewer. It is below the basement floor level, and can receive the discharge from any piece of apparatus either at the basement or at the first floor level.

There is an 8-inch tubular well 100 feet deep passing through the floor of this tank for experiments on the efficiency of various forms of deep-well pumps and air lifts.

The four half-tones, Figs. 28, 29, 30 and 31, give a very good idea of the hydraulic laboratory. The first mentioned is a view in the basement and shows the lower portion of the pressure tank,



[NOTE.—Since the above drawing was made, the following machines have been placed in the vacant spaces: 15,000-lb. wire tester, torsion machine, bending machines, cold-bend machine, pendulum torsion machine.]

Fig. 34.—Arrangement of Testing Machines, Room 102.

at the extreme bottom of which is an inlet connection, above which the tank gradually flares out until it reaches its full diameter. By this means the velocity of the water passing through the inlet valve is reduced, gradually and without agitation, to the small velocity required in the much greater cross-section of the tank. The archways at the right are entrances to the space under the weir tanks, which is used for storage. Alongside of the pressure tank, and just above the circumferential riveted joint, can be seen a supply pipe entering one of the concrete weir tanks.

Fig. 29 is a view on the floor next above, that

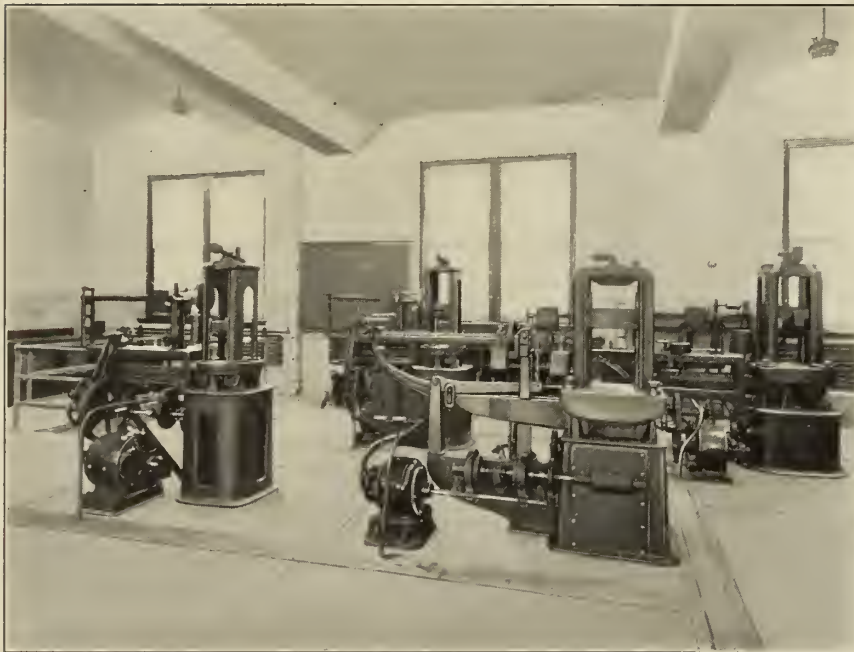


Fig. 35.—Universal Testing Machines of Capacity from 30,000 lbs. to 100,000 lbs., in Material-Testing Laboratory of C. E. Department.

is, the first floor. It is taken from the discharge end of the weir tanks, the gates being visible in the immediate foreground. At the far end of the left-hand tank can be seen the inlet T, through which the water enters from the connection seen in Fig. 28. This T is, on the side next the wall, perforated with numerous small holes, so as to eliminate as far as possible the disturbing effect of the current of water entering the tank. The shaft with sheaves, seen crossing the tank, is for lifting valves in the bottom for emptying them; this arrangement was not completely rigged up at the time the picture was taken.

The weir tank is also used to receive the discharge from orifices, one of which may be plainly seen in the pressure tank.

Fig. 30 is a view showing the upper end of the pressure tank in room 216 on the second floor.

In Fig. 31 at the upper left-hand corner can be seen a small portion of the chutes which regulate the discharge into the weighing tanks of the water received from the weir tanks. One of the latter is also visible in the illustration.

The pumping plant consists of three centrifugal pumps, indicated in Fig. 26, and plainly shown in Fig. 31, direct driven by variable-speed motors, which can be operated separately or combined and at various speeds. The switches and controlling apparatus can be seen mounted on the wall at the right of Fig. 31.

A 12-inch stand-pipe is provided extending from the basement to a height of about 65 feet or a little above the main roof, being 50 feet above the main working floor. This pipe is shown in Fig. 27 and is offset just below the third floor, as



Fig. 36.—Bins and Mixing Tables, Testing Cement Laboratory.

shown in Fig. 30, in order to avoid making an obstruction in the room above. Extending through the hydraulic laboratory are pipes with numerous connections to supply water to various pieces of apparatus as desired.

As can be seen from plans, the pressure tank

extends up through the first and second floors, and it is provided in the room on the second floor (Fig. 30) with additional orifices similar to those down below at the first floor (Fig. 29). These orifices and their fixtures are of quite in-

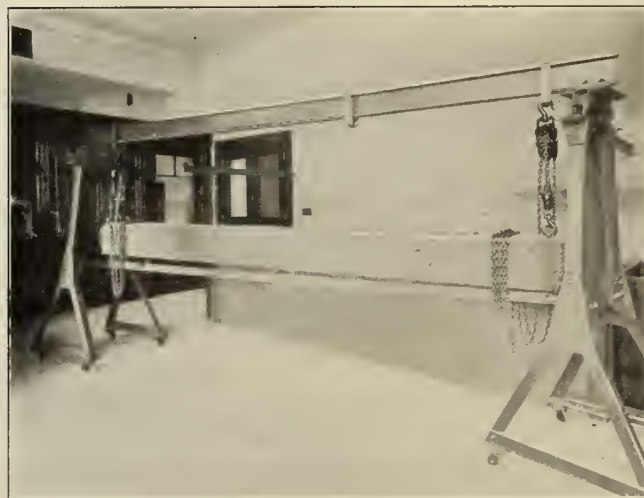


Fig. 37.—Concrete Beam Crane and Large Immersion Tank, in Testing Cement Laboratory.

teresting design, being so made that they can be changed with pressure on the tank without having to discharge the contents. As such a change will, in the course of the experiments, have to be frequently made, there is therefore a great saving of time and power because it is unnecessary to empty

and refill the tank. The device is shown in Fig. 32, Fig. 33 showing most of the details of it and also the orifice plates *M* themselves, which are 14 in number and have round, square and triangular orifices of various sizes, from 0.05 foot to 0.4 foot diameter. The outside of the orifice plate is threaded 12 per inch and screws into the orifice holder *N*, so that its face is flush with the inner end of the latter. The orifice holder has a short triple thread, 3 inches pitch, on its outer surface and is screwed into the main casting *P* with a special spanner *T*. To serve as a nut there are pins *S S S*, Fig. 32, which engage with the three short screw-threads on *N*. A stuffing box outside of the orifice holder provides against leakage. Inside the tank set in the inner face of the main casting *P*, is a disk or rotating gate *Q* with a stem projecting through another stuffing box to the outside, to permit of its being turned to either shut off the water from the orifice or to bring an opening *R* in the disk opposite the orifice. When the gate is closed, the holder is set up tight against its scraped surface, making a joint practically watertight and permitting the insertion of the orifice plate into the holder. The holder must be slacked back slightly in order to permit of opening the gate. This accomplished (the orifice plate of course now being in the holder), the holder is screwed in farther by means of the spanner *T* (which does not interfere with the outflow of

water), so that it projects through the opening in the gate. The design is such that when set up as just described a very smooth surface is presented to the flow of the water, so as to avoid any obstructions interfering with the formation of the jet.

This orifice device was designed by William Easby, Jr., assistant professor of civil engineering. A device used at McGill University suggested the circular rotating gate. The parts are made of bronze.

Next south of the hydraulic laboratory in the basement are small laboratories, repair shop, geodetic laboratory and room for surveying instruments (Fig. 2).

On the first floor south of the hydraulic laboratory is the testing laboratory of the civil-engineering department, which contains the principal material-testing machines. In this laboratory, of which a plan is given in Fig. 34, and a view of part of it in Fig. 35, are several universal testing machines of various types, ranging in capacity from 30,000 to 200,000 pounds, besides machines for special forms of tests, and foundations are being prepared for an immense vertical testing machine of 600,000 pounds capacity, which will be set in the basement and extend up through the first floor.

The room at the southeast corner on the first floor is a very completely fitted up laboratory for testing of cement, mortars and concrete, containing testing machines of various types for tensile, com-

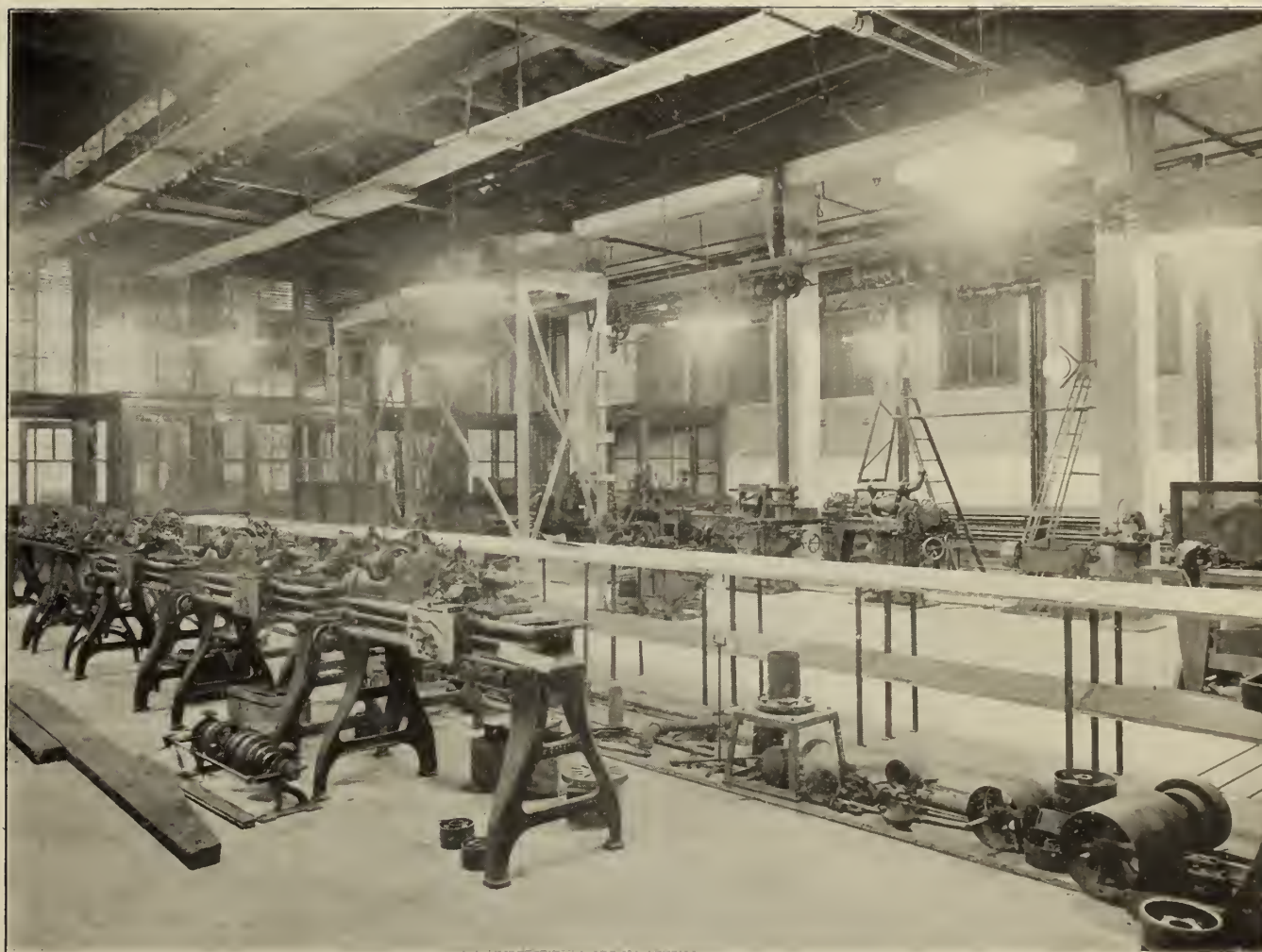


Fig. 38.—Reproduction of a Night Photograph of Machine Shop, taken by Electric Light, Showing the Excellent Distribution.

pressive and bending tests, a briquette-making machine, immersion tanks, damp-closets, etc., and a number of individual work tables, each completely equipped with an outfit of minor

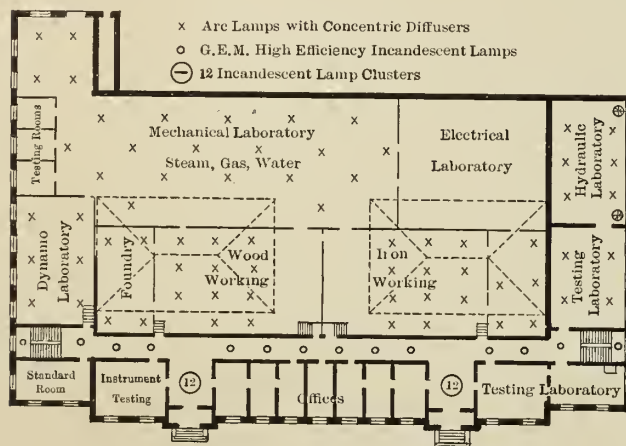


Fig. 39.—Location of Lights—First Floor.

apparatus. Fig. 36 is a view in this laboratory. Special provision is made for investigating the properties of plain and reinforced concrete. In Fig. 37 is shown a crane made for carrying concrete beams, and a large immersion tank. When the beam is ready to test it can be carried to the testing machine by the use of this crane, which is provided with wheels or casters.

The other rooms of the civil-engineering

department are sufficiently indicated on the floor plans. The drawing-rooms are similar in arrangement to those at the western end, although smaller, and the standard drawing table of this department

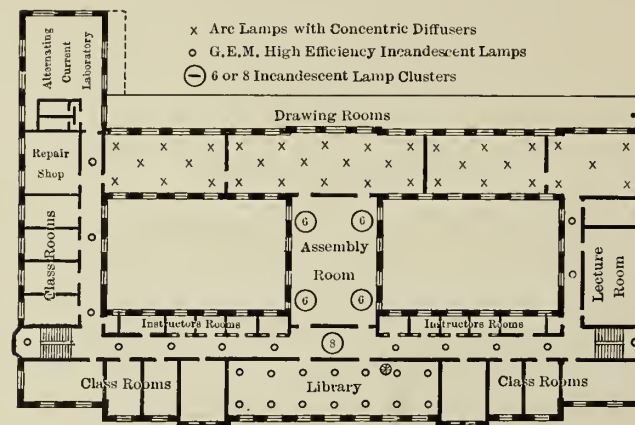


Fig. 40.—Location of Lights—Second Floor.

differs only in detail from that of the mechanical-engineering department shown in Fig. 21.

ILLUMINATION*

The artificial lighting of the engineering laboratories recently dedicated at the University of Pennsylvania affords an excellent example of

*This description was prepared by the General Electric Co., and printed in the AMERICAN MACHINIST of December 27, 1906.

the results obtained in that growing branch of the electrical art—illuminating engineering. Every room in this modern structure has been the subject of careful study from the lighting standpoint and as a result the new laboratory is probably the best lighted in the world.

Both arc and incandescent lamps have been combined to produce this result; arc lamps of the enclosed type with concentric diffusers being used for illuminating the larger areas, while the G.E.M. high-efficiency lamps with Holophane Pagoda shades, and ordinary incandescent lamps, used singly and in clusters, have been adopted for lighting hallways, lecture rooms, etc.

The new building (which is described above) with basement and three stories of rooms having various lighting requirements, presented a nice problem for the illuminating engineer, and the installation because of this varied character is typical of modern lighting practice. Within the building are machine shops, drawing-rooms, laboratories, offices, lecture rooms and library, each group exacting certain lighting values.

THE ILLUMINATION IN THE SHOPS AND LABORATORIES

The basement, containing rooms for storage, lockers, etc., is lighted by ordinary incandescent lamps and requires no special mention. On the first floor, however, the illuminating plans are

noteworthy. Here are located the principal mechanical and electrical laboratories and the shops, as well as various small laboratories and offices. The mechanical laboratory, with heavy machinery and wide open spaces, requires a general, brilliant illumination with the light so diffused as to prevent shadows behind machines. For this purpose enclosed arc lamps have been installed of the type made by the General Electric Company, equipped with concentric diffusers. The diffuser consists of a circular sheet-iron reflector, in the form of a broad inverted cone, the white enameled surface being corrugated in concentric circles, designed so as to distribute the light from the arc below to best illuminate the floor beneath.



Fig. 41.—Hallway Lighted by Incandescent Lamps with Holophane Globes.

In the wood-working, iron-working and forge shops, and in the dynamo, testing and hydraulic laboratories, on the first floor, conditions prevail similar to those obtaining in the mechanical laboratories. Arc lamps with concentric diffusers are therefore used, arranged as indicated in Fig. 39. The excellence of this illumination can be seen in Fig. 38, which is reproduced from the original photograph taken by the light of the lamps. The absence of shadows, and the even distribution of the light are particularly marked. Scattered incandescent lamps are available for lighting parts of machines and work.



Fig. 42.—Drafting Room Illuminated by Arc Lamps.

HALLWAYS LIGHTED BY INCANDESCENT LAMPS WITH HOLOPHANE GLOBES

The hallways form another problem in lighting, which in this instance has been interestingly worked out by the use of high-efficiency incandescent units combined with a concentrating reflector. The units are of the No. 4 G.E.M. type utilizing 187 watts and concentrate 180 candlepower in a downward direction by means of No. 5 Holophane Pagoda reflectors. This method of lighting is well adapted to the long, comparatively narrow corridors, and the excellent results so obtained are indicated in Fig. 41.

DIFFUSED ILLUMINATION BY ARC LAMPS IN THE DRAFTING ROOMS

In Fig. 40 is shown the lighting plan of the second floor. On this and the third floor the drafting rooms present the most interesting feature. From the nature of the case, the illumination in these rooms must be the best, pure, brilliant and well diffused, so that work can be done accurately by artificial light. The enclosed arc lamp with concentric diffuser has been selected for this purpose with the result shown in Fig. 42. This illustration is also taken from a night photograph, and the sharpness of the illumination obtained, combined with the evenness of the distribution, is striking.

THE LIGHTING OF OTHER LARGE ROOMS

Aside from the drawing-rooms, the rooms on the second and third floors incorporate other instructive features in illuminating engineering. The assembly room on the second floor is lighted by four six-light incandescent clusters, located as shown in Fig. 40. The illumination so produced is soft and even, the chief requirement being a soft general illumination which does not distract the eyes. The library on the same floor is lighted by G.E.M. units, as are the halls on this floor, and in the first story. The light here is stronger than in the assembly room, but at the same time is soft and well diffused and restful, quite in keeping with the purpose of the room.

On the third floor are the museums and auditorium, both lighted by incandescent lamps arranged in clusters. General illumination is,

of course, the chief requisite here. The hallway on this floor is lighted by G.E.M. units.

TABLE OF THE LAMPS AND AMOUNT OF ELECTRICAL ENERGY APPLIED IN EACH CASE

In order to make the comparison of illuminating value more convenient, the following tables have been prepared showing the character and dimensions of the room, the unit of illumination, and the watts per square foot. It will be seen that the drawing rooms require the greatest amount of light averaging 2.65 watts per square foot, while the shops come next, with an average of 1.8 watts per square foot of floor area. With these figures as a basis it would be quite possible to figure the amount of current necessary to light any building satisfactorily to meet different conditions, providing the floor area were known.

For additional information relating to the Courses in Mechanical and Electrical Engineering apply to Professor H. W. Spangler, and for Civil Engineering to Professor Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

FIRST FLOOR

Room.	Unit of Illumination.	Dimensions of Room.	Watts per Square Foot.
Mechanical laboratory.....	22 arc lamps with concentric diffusers.....	{ Main 162 x 63 ft. Bay 37 x 39 ft.	1.0
Electrical laboratory.....	2 high-efficiency 187-watt G. E. M. units. 94 16-c. p. incandescent lamps.....	72 x 63 ft.	1.22
Dynamo laboratory.....	6 arc lamps with concentric diffusers. 18 16-c. p. incandescent lamps.....	62 x 38 ft.	1.82
Work shops.....	52 arc lamps with concentric diffusers. 42 16-c. p. incandescent lamps.....	213 x 51 ft.	1.84
Hydraulic laboratory.....	6 arc lamps with concentric diffusers. 13 16-c. p. incandescent lamps.....	63 x 38 ft.	1.68
Testing laboratory.....	14 arc lamps with concentric diffusers. 11 16-c. p. incandescent lamps.....	46 x 38 ft.	1.6
Testing laboratory offices, standard room, etc.....	84 16-c. p. incandescent lamps.....	6300 sq. ft.	0.72
Corridors.....	14 high-efficiency 187-watt G. E. M. units. 24 16-c. p. incandescent lamps.....	3741 sq. ft.	1.05

SECOND FLOOR

Drawing-rooms	{ 18 arc lamps with concentric diffusers.....	58 x 31 ft.	2.45
	{ 14 arc lamps with concentric diffusers.....	93 x 31 ft.	2.68
	{ 8 arc lamps with concentric diffusers.....	58 x 31 ft.	2.45
	{ 5 arc lamps with concentric diffusers.....	46 x 31 ft.	1.92
Library.....	14 high-efficiency 187-watt G. E. M. units.....	98 x 28 ft.	1.0
Assembly room.....	24 16-c. p. incandescent lamps.....	44 x 63 ft.	0.48
Corridors.....	12 high-efficiency 187-watt G. E. M. units. 8 16-c. p. incandescent lamps.....	11 x 300 ft.	0.81

THIRD FLOOR

Drawing-rooms.....	{ 14 arc lamps with concentric diffusers.....	87 x 38 ft.	2.33
	{ 17 arc lamps with concentric diffusers.....	116 x 31 ft.	2.6
	{ 13 arc lamps with concentric diffusers.....	80 x 31 ft.	2.88
	{ 9 arc lamps with concentric diffusers.....	59 x 31 ft.	2.7
Museums.....	24 16-c. p. incandescent lamps.....	62 x 39 ft.	0.55
Auditorium.....	40 16-c. p. incandescent lamps.....	2772 sq. ft.	0.8
Corridors.....	{ 10 high-efficiency 187-watt G. E. M. units. 8 16-c. p. incandescent lamps..... { Arc lamps 5 amps., 110 volts D. C.....	11 x 300 ft.	0.7

TABLE SHOWING NUMBER AND KIND OF LAMPS, SIZE OF ROOM, AND CURRENT CONSUMPTION.

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